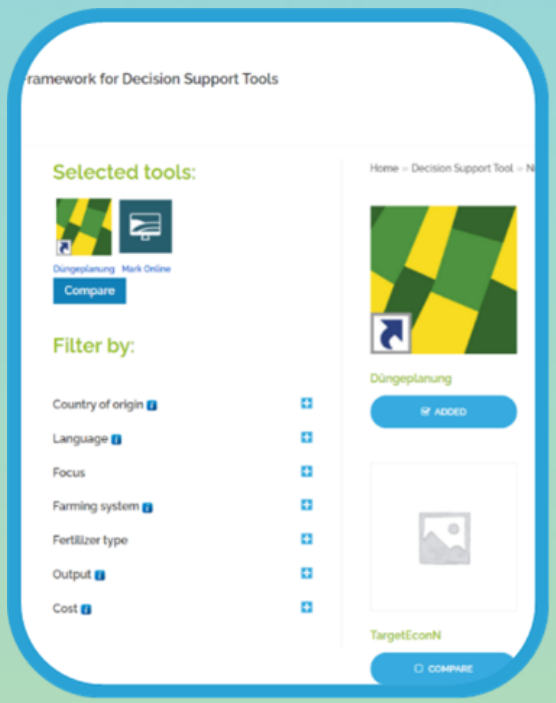
FAIRWAY
Farm System Management and Governance
for Good Water Quality and Drinking Water Supplies

FAIRWAY REPORT series



Development of a Decision Support Framework

M. L. Madsen, R. K. Laursen, L.K. Thostrup, L. Tendler, J. R. Williams, I. Wright, P. Schipper, K. Verloop, G. Clements, M. Hoogendoorn, F. Nicholson, J. Brandt, D. Donnacha, L. Farrow, G. Velthof

SEGES, DK

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EXECUTIVE SUMMARY

A framework for cataloguing and describing 30 decision support tools (DST) used in the Fairway case study sites has been developed. The DST framework is a web-based interactive user interface that allows the user to find and compare DSTs from countries participating in the Fairway project. The Framework provides a platform for knowledge sharing to facilitate wider use and future development of DSTs. The DSTs support nutrient and pesticide management which are key to the Fairway objectives to establish common awareness and action among farmers in relation to diffuse pollution of vulnerable drinking water resources.

The DST framework is based on the outputs of WP5.1, 5.2 and 5.3 which identified, tested, and evaluated DSTs available to farmers and policy makers in all participating countries. The DST framework was developed as an integrative framework that is easy and quick to use and allows DSTs used in the participating countries to be compared. An important consideration of the framework development was the need to encourage target groups to improve and develop existing and new DSTs.

The output from task 5.4 is a user-friendly, interactive web-based DST framework. The user can easily click forward in the menus of the framework to compare functionality and technical spects of different DSTs. The framework also includes information sheets with links and contact details for key workers involved in the use and development of the DSTs. The framework identifies differences in presentation and technical working between DSTs enabling the sharing of information to encourage development of existing and new DSTs. The web-based system can be maintained in the future by integrating improvements of existing tools and updating the database with new tools as they become available.

1. AIM AND OBJECTIVES

The aim of Task 5.4 was to develop a decision support framework for advice, training, and communication strategies to establish common awareness of diffuse pollution of vulnerable drinking water resources among farmers and other actors that may use these DSTs.

In order to establish common awareness and action on how to handle diffuse pollution in different cases, a number of difficult decisions were taken on when and how to take the different steps. In this task we developed a framework which includes a collection of existing DSTs that support management practices to reduce diffuse pollution of pesticides and nutrients including nitrate to surface and groundwaters from agriculture. The framework provides a catalogue of DSTs which allows different actors to identify appropriaite DSTs and provides a platform for developers and other interested parties to compare and further develop DSTs. As a part of the evaluation we considered trade-offs to other environmental issues, such as ammonia (NH_3) emissions to air, soil fertility and biodiversity. Most DSTs for nutrients are not restricted to drinking water resources and estimate nutrient loads or give information about how to improve nutrient use efficiency from applications or organic materials and manufactured fertilisers which will minimise nutrient losses to ground and surface waters. Most pesticide tools are not restricted to drinking water resources either and also do not estimate pesticide loads or give information about how to reduce pesticide loads to surface waters.

The experiences from the evaluation of the functionality of different decision tools in Task 5.2. and the cost-benefit analyses in Task 5.3. served as input data for setting up the framework. The previous tasks identified how and when the different tools can be used for establishing a common awareness among farmers of diffuse pollution of vulnerable drinking water resources. We considered restricting the framework to tools used just by farmers and farm advisors as originally planned since these tools have a high degree of practical relevance. However, it was decided that it would also be helpful to include tools suitable for other actors such as catchment scientists, policy makers and tool developers to provide awareness of different approaches to tool development and functionality.

Task 5.4 also drew on outputs from T5.1, T5.2 and T5.3 to highlight ways in which DSTs can quantify nutrient or pesticide losses to water resources from agriculture and to identify effective mitigation measures. Application of the DSTs is useful to improve awareness of diffuse pollution of drinking water resources among farmers, agronomists, farm advisors, water quality managers, policy makers, fertiliser and pesticide maunfacturers and suppliers, researchers/model developers and other stakeholders. This report from T5.4 describes the development of the decision support framework and presents a synthesis of WP5. This framework can be used for selection of DSTs in a range of different contexts and provides the opportunity to maintain the platform after the Fairway project period.

2. APPROACH AND METHODOLOGY

Task 5.4 is a continuation of Task 5.1 – Task 5.3. In Task 5.1 a literature survey (long list) and review of the existing DSTs used by farmers, farm advisers, water managers and policy makers for water, nutrient and pesticide management in the project partner countries involved in this task, and elsewhere in Europe, was conducted. In most cases, the tools considered were used in our Fairway case studies and were of high practical relevance.

The review resulted in a shortlist selection of a set of 36 DSTs (see Table 5 in report D5.1, Nicholson *et al.*, 2018) that could be further assessed for their potential suitability for managing nitrate and pesticide losses to water within the case study catchments of the FAIRWAY project.

A set of information sheets (see delivery D5.1, Nicholson *et al.*, 2018) that summarised the operation and outputs of the tools were produced to provide an easily accessible source of key information on DST capabilities. A subset of the DSTs was demonstrated to a group of project partners and Multi Actor Programme (MAP) leaders at a workshop on the 17th of April 2018 at ADAS, Boxworth, UK. Videos of the presentations about the DSTs were made for dissemination to the other project partners. Additionally, a 'distribution key' (see milestone M5.1) was developed based on specified characteristics of each DST in the subset, i.e. targeting groundwater or surface water, nitrate or pesticides, and the target user e.g. to support regional policy makers or sustainable farm management. Moreover, DSTs were categorized based on their functionality (i.e. evaluation of current practices, strategic advice farm management and implementation of mitigation measures; operational management i.e. climate smart, innovations for equipment, IT-apps, instructions/rules for sustainable application).

Based on the information provided by Task 5.1 the case study leaders initially selected the DSTs they intended to demonstrate and/or test in their case study as a part of Task 5.2. The initial selection can be found in milestone M5.1.

As a part of task 5.2, 12 DSTs were tested in 9 of the Fairway case study sites located across different EU countries (see D5.2, Laursen *et al*., 2019). For instance, the Danish “Mark Online” was tested at case study no. 5 in Lower Saxony. The objective was to identify how fertilizer planning, documentation and control are undertaken in different countries and how the DSTs for that purpose are designed. “Mark Online” has similarities to “Düngeplanung” which is already used in Germany and was a useful comparator DST (To see a comprehensive report on this testing in German language go to: https://www.lwk-niedersachsen.de/index.cfm/portal/6/nav/203/article/32333.html). DSTs for pesticide management including “Plant Protection Online” (DK), “SIRIS” (FR) and the “Environmental Yardstick” (NL) were also compared and evaluated. Differences were identified, such as national range of pesticides and levels of accepted dosages. The comparisons allowed valuable shared knowledge between countries. A number of DSTs were tested in alternative contexts which showed that many countries have developed similar DSTs to address similar problems. The testing and evaluation were useful in identifying how existing DSTs in different case study areas could be updated and improved. Furthermore, in a few cases where no equivalent DST existed, the testing assessed the potential for a DST to be used in that country and to draw on the ideas presented.

The comparison also provided examples of how fertilizer/pesticide management works in other countries, as the tools reflected the national legislation and related implementation of the country of origin of the respective tool. Farmers were very interested in knowing if their management practices were in line with regulations set by other countries. The comparisons allowed them to identify if their own management was worse/better/in line with what happens elsewhere in the EU.

The process of testing DSTs led to a set of criteria for a successful DST (see D5.2, Laursen *et al.,* 2019, p22). The criteria to be fulfilled by a DST are about accessibility, user-friendliness,

functionality and the quality of the output from the DST. The criteria can serve as basis for assessment and comparisons of DSTs.

In Task 5.4 all information gathered was organised in such a way that allowed users quick and easy access. An online DST selector was designed which summarises basic information on the tools and provides several quick search options to identify DSTs of potential interest. Furthermore, this framework can establish more and better application of DSTs, inspire developers to improve existing DSTs and enhance exchange between scientists and farm advisors in further development of DSTs. The framework was elaborated in close cooperation with other deliverables. D5.7 is a description of a DST framework for advice, training, and communication strategies and D5.5 consisted of a Phone App for pesticide management. The D5.6 is a scientific publication about DSTs and furthermore a workshop on learnings from case studies of DSTs will be completed.

2.1 OVERALL WORKPLAN

In Task 5.4 the focus was on developing a decision support framework and the work was divided into phases.

1: Selection of technical solution.

At the beginning of this task, considerations were taken to find a technical solution that could meet project requirements. A decision tree model was discussed, but it was decided that it was not possible to identify the normative hierarchy of the importance of different aspects of the DSTs in this model. Furthermore, the decision tree model was too slow to meet criteria of user friendliness. Instead, it was decided that the framework should be constructed as a large grid with an algorithm that automatically gives an outcome when the user has answered some questions and selected different selection criteria. The framework was based on an excel sheet with a simple layout. It was a premise that the framework should be easy and quick to handle, and that it should provide a good overview for the user after just some clicks. The system needed to be easily updated as tools become redundant or when new and updated tools are introduced. In addition, there needed to be a hosting platform that might continue after the end of the Fairway project.

2: Target groups

Due to the complexity and the site-specific limitations of different national anchoring, it was decided to increase the target group of the DST framework users to:

- Farmers
- Farm advisors
- Catchment managers
- Policy makers
- Researchers
- DST developers

The framework provided a catalogue of DSTs that could be used by developers to build new or improve existing tools.

3: Prototype testing

Tests of first versions of the framework were conducted by project members of WP5 and a feedback process tuned the basic functionalities in the framework. It was decided that the framework should include an open-source element, so that future DSTs can be integrated to ensure a dynamic platform that can sustain its relevance after the end of the Fairway project. The

future perspectives also led to the choice of the partner CLM as a host for the framework since they could offer a more future-proof platform than the Fairway website.

Once the prototype of the framework had been produced, it was clear that the framework had to be split between “tools for pesticide management” and “tools for nutrient management” with two separate filter solutions. This was a logical consequence caused by the technical complexity of the two different datasets. In addition, as the target groups focus was likely to be different, it was reasonable that the comparison between DSTs would be clearer for end users if the datasets were kept separate in the framework functionality and user interface.

4: Securing input data

Following construction of the framework a process for quality assurance and updating of the original information sheets was conducted. The information sheets compiled in T5.1 were reviewed by the study area partners and in special cases examined in cooperation with the DST owners (See appendix 8.1 for example). In addition to the DST information sheets we asked DST providers for additional information, covering information on DST maintenance, updates, ease of use, time requirement, data and network requirements to run the tool and additional demonstration material (interface, output, etc.). This process ensured the data in the grid behind the final version of the DST framework, allowed comparative functionality and were in accordance with the current development of the individual DSTs.

5: Applying and finishing the DST framework

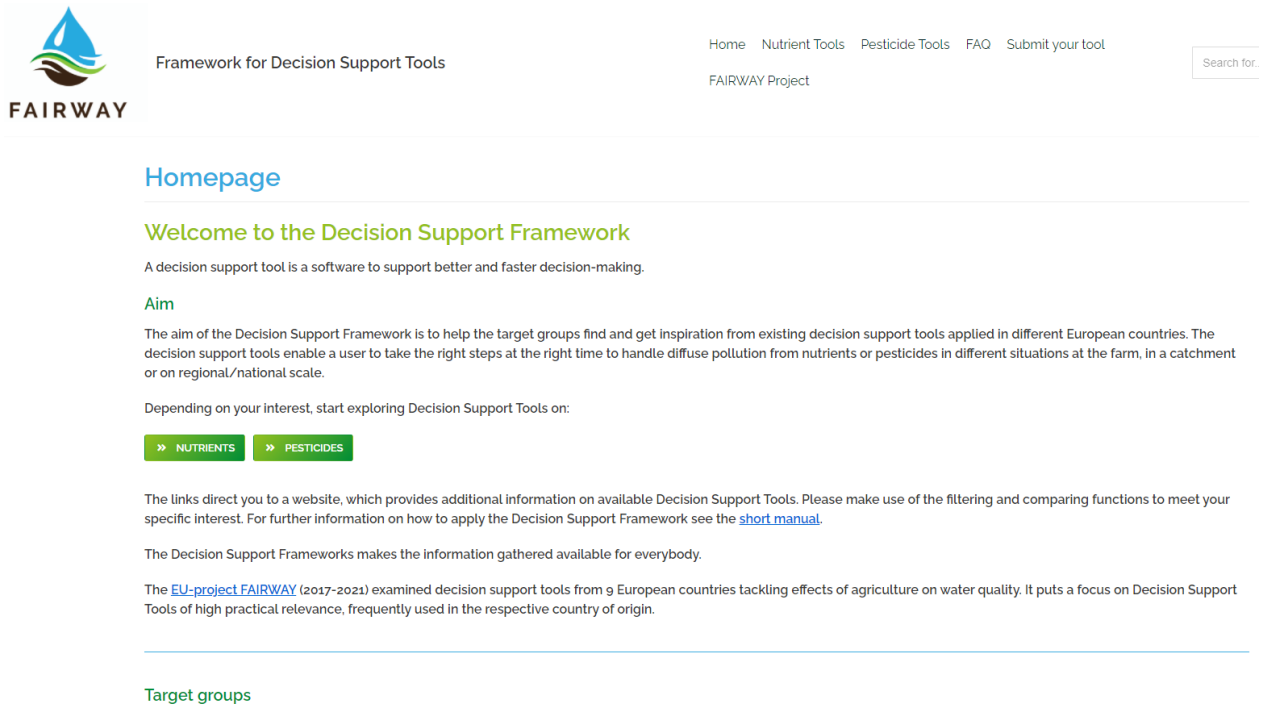
After the quality assurance process, the validated data of the information sheets was incorporated in an updated version of the DST framework. The updated version was tested and validated by case study partners and the updated version of the DST framework was launched at the end of May 2021.

3. RESULTS

The updated version of the Framework for Decision Support Tools is hosted at CLM and is based on 30 DSTs divided into two sections concerning nutrient management and pesticide management. On the introduction page of the framework the user is met with information on:

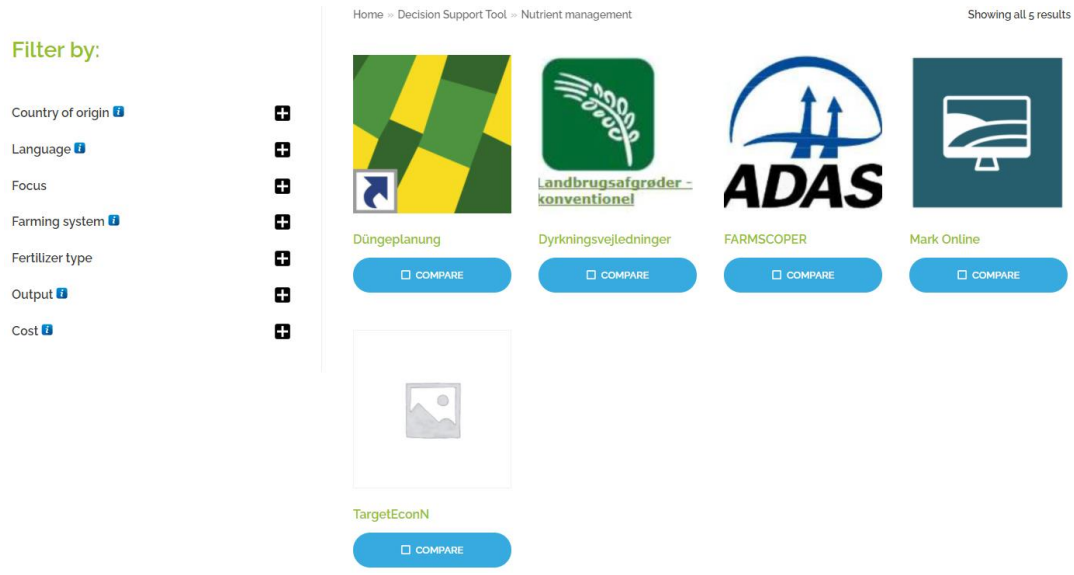
- Aim of the framework
- Target groups
- Publications supporting the Decision Support Framework
- Maintenance
- How to submit a new tool (contact to add or edit content)

Those sections provide links for possible downloads, demonstration materials and contact information and there is a link to a short manual for the users (https://www.clmtest.nl/decision-support-%20tool/?swoof=1).



1: DSTs for nutrient management

When the user clicks on the nutrients tab to search for DSTs on nutrient management, they are directed to a list of possible DSTs to assess and compare. The left side of the page includes a filter option connected to drop-down menus. “Country of origin” and “Language” are initial options. In “Focus” the user can choose between tools for farm management, water catchment management and tools for regional/national policy advice.



In “Farming system” the user can choose between arable, livestock or mixed farming systems, and in “Fertilizer type” there is a choice between mineral or organic fertilizers.

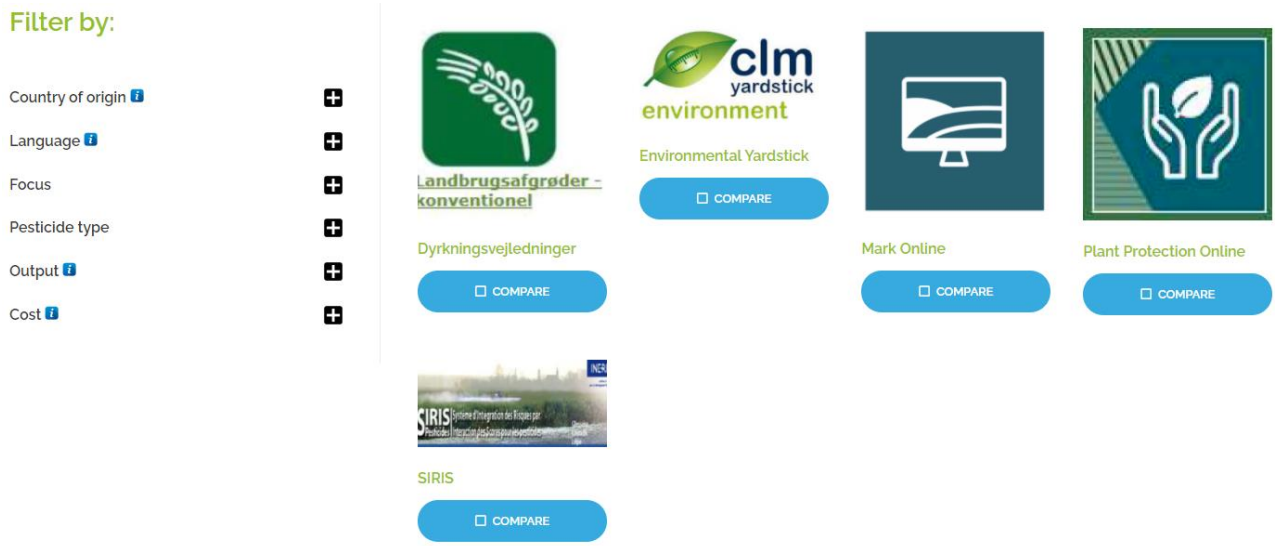
The drop-down menu under “Output” gives three options: “Recommend on individual farm management”, “suggest mitigation measures to reduce nutrient losses” and “estimate expected environmental impact”, which reflect which level you as a user want your selected tools to provide information on.

	Düngeplanung	Mark Online	Dyrkningsvejledninger
			
Description	Developed in: Germany, by 'company XYZ' Responsible person from FAIRWAY: Linda Tendler (Landwirtschaftskammer Niedersachsen, DE) www.url.com	Developed in: Denmark Responsible person from FAIRWAY: Rikke Krogshave Laursen (SEGES, DK)	Developed in: Denmark Responsible person from FAIRWAY: Rikke Krogshave Laursen (SEGES, DK)
Attributes			
Country of origin	Germany	Denmark	Denmark
Language	German	Danish	Danish
Focus	Tools on farm management	Tools on farm management	Tools on farm management
Farming system	Arable	Mixed	Arable
Fertilizer type	Mineral / manufactured materials Organic materials	Mineral / manufactured materials Organic materials	Mineral / manufactured materials Organic materials
Output (nutr.)	Recommend on individual farm management	Recommend on individual farm management	Recommend on individual farm management
Cost			Free
Other attributes			
Product categories	Nutrient management	Nutrient management	Nutrient management
Factsheet	Factsheet Dungeplannung		

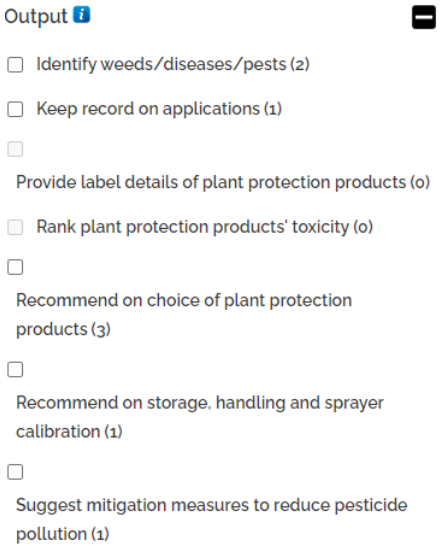
When the users have made their choices on the drop-down menus, they can activate the “Compare” functionality and the framework automatically produces a sheet that compares the DSTs that complies with the chosen criteria. This sheet links to factsheets for each DST, where additional information and links for the web pages or contact details of the DSTs are provided.

2: DSTs for pesticide management

The other section of the framework concerns DSTs for pesticide management. The functionality is parallel to the nutrient management- section, but other drop-down menus are provided relevant to pesticide management.



The “Pesticide type” menu offers “Fungicide”, “Herbicide”, “Insecticide” or “All” as filtering options. Furthermore, the “Output” drop-down menu provides seven options that suggest outputs on identification of the problem, recommendations on solutions and practice as well as mitigation measures



In the background of the chosen categories in the drop-down menus, the output window for comparison of the DSTs shows the data of the relevant DSTs and links to information sheets and further information on the web pages. For an example of an information sheet see appendix 8.1. The functionality provides the user easy access to all available DSTs connected to the DST Framework.

3: Future of the DST Framework

It is intended that the framework can continue to be used and updated after the Fairway project has been completed. The intention is that osolete or redundant tools can be removed at no cost

and that updated, and any new tools can be integrated at a modest cost. It may be appropriate to discuss the possibility of DG Agri hosting the framework after the Fairway project is finished https://ec.europa.eu/info/news/new-tool-increase-sustainable-use-nutrients-across-eu-2019-feb-19_en.

4. DISCUSSION

Testing of DSTs in task 5.2 identified differences between countries concerning legislation and between national constraining factors in both nutrient management and pesticide management. The testing also showed that the developers of tools could learn and enhance DSTs by comparing the functionality and technicality of tools used in different EU countries. Farmers expressed interest in adding functionalities of other tools to the existing tools that they already use but were less interested in more (new) tools. The DST Framework provides an instant access to compare the functionality of tools, and to find an appropriate contact person who can provide more details on the specification and use of each tool. The target groups for each tool are most often embedded in national context but the DST Framework makes it easy to find new parallel DSTs in other countries, and to find inspiration to improve the DSTs, potentially in cooperation across borders.

Furthermore, the DST Framework provides the opportunity to add new and additional existing DSTs to the framework like the FaST tool developed by the EC, which ensures a dynamic platform that can be maintained in the future. This will help demonstrate the positive contribution that DSTs have on supporting management practices that reduce nitrate and pesticide losses to drinking water from agricultural systems. From an overall perspective the criteria for DSTs, namely accessibility, user-friendliness, functionality and quality of output (see D5.2, Laursen *et al.,* 2019, p22) are all criteria that can be applied to the DST Framework as well. Some of the recommendations later in this report reflect possible improvements for the DST framework seen from the perspective of these criteria.

4.1 TRADE-OFFS TO OTHER ENVIRONMENTAL ISSUES

DSTs typically have specific focus and the information provided to control nitrate and pesticide losses may have positive or negative impacts on other pollutant pathways. Some possible benefits and trade-offs of management practices that reduce nitrate and pesticide losses include:

- Reduced tillage (as a measure to reduce nitrate leaching) might result in higher weed pressure and an increased use of pesticides and vice versa.
- Cover crops are very effective at reducing nitrate leaching but if they do not die over winter, it may be necessary to apply herbicides to clear the ground before establishment of the following cash crop.
- Reduced dosages of pesticides and frequent repetition of limited active ingredients may lead to resistance in diseases and pests. In time this may increase the amount of pesticides applied and encourage the use of more effective (but maybe more toxic) pesticides.
- Increasing nutrient use efficiency typically encourages the use of manufactured instead of organic fertilizers since manufactured N-fertilizers can be applied more targeted. However, the sustainable use of organic fertilizers reduces the need for manufactured fertilizer applications to meet optimum crop requirements, increases (soil) biodiversity

and reduces consumption of oil and gas (which is used to synthesize mineral N fertilizers)
- The use of DSTs often requires additional time – which may restrict use on farms or require employing a farm advisor. The additional cost associated with using the tool and interpreting the results may be offset by reductions in fertilizer and pesticide use.
- Costs and practicalities associated with precision farming techniques may restrict their use to larger farms.
- It is important to consider the impacts of practices that reduce water pollution losses to air (MANNER-NPK includes ammonia and nitrous oxide emissions).

The trade-offs reflect the complexity of the impacts that decisions made by farmers and policy makers on nutrient and pesticide management have on diffuse pollution from agricultural systems. DSTs play an important role in encouraging good farm practice and informing policies to achive the best outcome for reducing nitrate and pesticide losses to water.

5. RECOMMENDATIONS

The DST framework developed in task 5.4 can be used to select DSTs for optimal nitrogen and pesticide use.

The DSTs in the framework cannot necessarily be applied across all countries due to differences in national legislations, but the framework makes it easy to get a rapid overview of DSTs and to share knowledge of DSTs between countries. The framework provides a good overview of how DSTs in other countries work and can help to harmonise advice for farmers to optimise pest and nutrient management. The framework can be used to inspire developers to add useful parts / functionalities into existing tools.

Recommendations for future:

- Link Fairway with DG Agri and the FaST tool.
- Connect to the From Fork to Farm strategy of the European Commission: (https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/farm-fork_en) with ambitious targets of nutrient and pesticide reduction (DSTs are needed to reach these targets).
- Include potential trade-offs in development and use of DSTs.
- Add new tools and updates of already included tools
- Keep framework alive after FAIRWAY.
- Establish procedure and criteria for adopting and excluding DSTs in the framework.

As the demands of policy and environmental regulations change and the availability and access to data increases, it is likely that DSTs will become more popular in the future. Maintaining the framework after the end of the project will be useful to help future development of DSTs.

6. CONCLUDING COMMENTS

Task 5.4 has produced a Decision Support Framework that integrates the Decision Support Tools from the case study sites of the Fairway project.

Following a thorough consideration of possibilities, a Decision Support Framework was developed and tested. The DSTs included in the framework were a mixture of farm level tools aiming to improve nutrient and/or pesticide management, and catchment/regional level DSTs aiming to assess risk and cost-effectiveness in the field of nutrient and pesticide measures. The DSTs were identified and tested in earlier Fairways WP5 tasks.

The selected DSTs were updated and checked by case study partners before being included into the framework.

The user-friendly web-based, interactive DST Framework allows users to compare DSTs and share knowledge that can facilitate the development of existing and new DSTs. The framework can be maintained in the future and serve as a platform for comparison of and inspiration for DSTs in the future.

7. REFERENCES

Deliverable 5.1. (2018) Survey and review of the decision support tools. https://www.fairway-project.eu/index.php/downloads/category/14-deliverables

Deliverable 5.2. (2019) Evaluation of decision support tools. https://www.fairway-project.eu/index.php/downloads/category/14-deliverables

Deliverable 5.3. (2019) Assessment of costs and benefits using DSTs. https://www.fairway-project.eu/index.php/downloads/category/14-deliverables

8. APPENDIX

1: Example of an information sheet. Each DST in the DST framework is based on the information from an information sheet

Düngeplanung 1.6 **FAIRWAY partner: Linda Tendler (Landwirtschaftskammer Niedersachsen, DE)**	
Brief description	
A farm-holistic DST which helps to identify the total amount of fertilizer to be purchased and its field-specific distribution. It combines measured on-farm data (soil nutrient contents, farm manure analysis, etc.), information on crop cultivation (crop rotation, yield level, etc.) with economic implications (e.g. fertilizer prices).	
Contaminants covered (e.g. nitrate, pesticides etc.)	Nitrate (phosphate)
Intended end users (e.g. farmer, water quality manager, policy maker)	Farmers and advisors
Level of expertise and/or training required	Some basic training and agronomic expertise required. However, the application is mostly "learning by doing"
Geographical resolution (e.g. field, catchment, national)	Field scale.
Temporal resolution (e.g. daily, annual, long-term).	Annual
Real-time component (e.g. live weather data, soil moisture data feeds etc.)	None
Number and type of mitigation measures included	Comparison of different fertilizing scenarios possible; Crop rotation and cover cropping (Cost-benefit comparisons of scenarios possible)
Platform (e.g. paper-based tool, phone app, bespoke software).	Bespoke software Up to now only available in German language
Frequency of updates	Infrequently, depending on feedback and legislative changes
Cost/availability	Available for all members of LWK but still in development phase
Number of users or number of copies distributed/ downloaded/purchased	About 50 – number will probably increase (LWK is currently advertising the application)
Links to demo material and other relevant information (e.g. user guides).	None available
Additional comments	

Düngeplanung 1.6 **FAIRWAY partner: Linda Tendler (Landwirtschaftskammer Niedersachsen, DE)**	
Input data required to run the DST	- **list of fields and their respective size*** - information whether some fields are located in water protected areas - **soil analysis (contents of humus, P, K, Mg, (CaO), ..)*** - **information about recent/long-term soil mineral nitrogen (Nmin)*** - **information about current crop rotation (and crop rotation in previous year)*** - **information on yield levels (crop-specific)*** - latest analysis of farm manure to be applied - (if cost-benefit comparison is requested: list of fertilizer price) - Type of fertilizer preferred by the farmer *mandatory
Outputs (including links to water quality and economic or financial aspects)	- Fertilizer plan (which crop, which fertilizer, which amount, which timing) - Overview of fertilizer to be purchased - Anticipated nutrient balance (N, P, K) of different fertilizing scenarios (given the yield level is met)
Age/provenance of supporting data used to develop the DST	- Based on official recommendations of LWK (data of several decades) - - values set by the national fertilizer ordinance
Country-specific calibration or data requirements (including restrictions on use)	National regulation (i. e. fertilizer ordinance) are considered - E.g. maximum N-requirements for crops according to legislation - Specific regulations in water protected areas
Details of validation and testing	Software tested by selected end users and validated by officials of authority of fertilization of Lower Saxony
Date developed/released (or planned release date)	First developed in 2014, testing and upgrade since 2015
Author/developer names and affiliations	Düngebehörde of LWK (Authority of fertilization of LWK); programming executed by GID Landwirtschaftskammer Niedersachsen (LWK Niedersachsen) (Agricultural chamber of Lower Saxony) GeoInformationsDienst GmbH, Rosdorf
Member state(s) where developed	DE
Member state(s) where currently used	DE
Key publication references	https://www.lwk-niedersachsen.de/index.cfm/portal/polaris-niedersachsen/nav/2179.html

Düngeplanung 1.6

FAIRWAY partner: Linda Tendler (Landwirtschaftskammer Niedersachsen, DE)

Any other useful information (e.g. screenshots of DST input/outputs)

Screenshot of program interface: List of fields with information on crop rotation.